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VACUUM TUBE DEVELOPMENT AT OBERSPREEWERKE AND ITS SIGNIFICANCE TO SOVIET ELECTRONIC DEVELOPMENTS

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VACUUM TUBE DEVELOPMENT AT THE OBERSPREEWERKE AND ITS SIGNIFICANCE TO SOVIET ELECTRONIC DEVELOPMENTS

The purpose of this report is to gather and integrate the information available up to the early part of 1949, concerning operations at the Oberspreewerke, Berlin-Oberschoeneweide, Ostend Str. 1-5. Information has been gathered from a multitude of individual reports from various sources, including a few reports integrating the situation at earlier dates. It is unavoidable that there be differences in the reliability of various parts of the information, but these have been minimized as far as possible. (See Bibliography for a listing of the more important source material.)

For convenience, the discussion is divided into the following main headings: I. Postwar Organization (tracing the details and changes of organization from 1945 to early 1949); II. Production Figures (limited chiefly to statistics on types and numbers of articles produced from 1946 to early 1949); III. Research and Development Program (details of the projects, priorities, and results, with indications of their relative importance to the whole program whenever possible); IV. Plans for the Future; and V. Conclusions (including a summary, a discussion of gaps in the information, and an estimate of the organization's place in the general scheme of things).

I. POSTWAR ORGANIZATION

After the German capitulation in May 1945, Soviet authorities planned immediately to raise the production level of German industry for the benefit of the Soviet Union. In the course of this program, the former radio-tube factory of the AEG "Oberspree," located in Berlin-Oberschoeneweide, was reopened as an independent radio-tube factory in August 1945. The original name was "Laboratorium, Konstructions -- und Versuchswerk Oberschoeneweide (LKVO)." Later it was generally known as the Oberspreewerke (hereinafter referred to as the OSW).

Over-all management was given to Dr. Karl E. Steimel, a former Telefunken executive. The program of the factory included not only research and production of radio tubes, but also instruments and parts for all high-frequency research, such as condensers, resistors, coils, crystals, rectifiers, etc. Research on the objects was to be completed at the OSW, but production was to take place in the Soviet Union. To that purpose a special Information Department was organized. All orders were placed by the Soviet Ministry for Electro-Technics, as represented by Colonel Katzmann. The original agreement between Katzmann and Steimel planned to examine all the recent research projects and unexploited patents of the AEG and Telefunken.

A second branch, known as the Nachrichtentechnische, Entwicklung und Fabrikation, under Dr. Martin Kluge, working on signal problems, was amalgamated with the LKVO, and the combined organization has been known for a considerable time as the OSW.

It was intended to enlist the help of a maximum of personnel, particularly those who were engaged in the original projects prior to May 1945. After a very short time, the services of a considerable number of highly skilled technicians and engineers were secured, most of them coming from other big German electrical and radio organizations. There were also a few foreigners among them who had worked in Germany during the war, such as the well-known Netherlands high-frequency expert, Dr. Hans Otto Roosenstein.

One of the most important inducements to personnel was the magnanimous distribution of foodstuffs to the employees. Other concessions were made in the matter of supplies, housing, and special money payments. All these economic advantages, plus hundreds of other facilities, resulted after one year in probably the best equipped and staffed research institute in Central Europe. The total staff at this time consisted of

more than 2000 skilled workers and scientists, some of them the leading German experts in the various fields of research. Of these, an estimated 200 to 300 were engineers and scientists.

In this period prior to the first large-scale deportation of German technicians to Russia, the organization of the departments was approximately as follows:

Russian Technical Director (Lt. Col. Boldyr)
Russian Administrative Director (Maj. Wildgrube)
German Directors (Dr. K. E. Steimel and Dr. Spiegel)

- Vacuum tubes (Dr. K. E. Steimel)
  - Transmitting tubes
  - Receiving tubes
  - Magnetrons
  - Gas-filled tubes
  - X-ray tubes
  - Cathode-ray tubes
  - Tube development
- Components (Christian Gruner)
  - Resistors
  - Condensers
  - Quartz-crystal oscillators
  - Magnetic materials
  - Test room
- Apparatus (Dr. Paul Kotowski)
  - Pulse techniques
  - Measuring apparatus
  - High-frequency technique
  - Installations
  - Test room
- General Technique (Dr. Max Richter)
  - Metal-ceramic technique
  - Metallurgy
  - Tungsten and molybdenum
  - Chemistry
  - Tests of materials
  - Technical development
  - Cathodes
- Workshops (Goslar)
  - Tube electrodes
  - Tube and circuit components
  - Machine and oven construction
  - Design and computing
  - Tools and equipment
- Manufacture
  - Tube-construction workshop
  - Machine-tool shop

Apparatus-construction shop
Glassblowing shop
Cathode construction
X-ray tube construction
Pumps
Standardization
Test room

Central Technical Department (Dr. Spiegel)

Circuits
Technical planning
Power and raw materials planning
Technical information section
Technical archives

Administration (Dr. Granitza)

Finance
General organization
Establishment
Buying section
Stores and despatch

On 21 October 1946, the first large-scale deportations of personnel to Russia took place. At this time, a total of 2000 to 2500 technicians and engineers were employed, including about 300 Russians who were studying German methods. From 250 to 500 of the engineers and technicians were deported to Russia on that date. This sudden evacuation, which was apparently as much of a surprise to the Russian officers in charge of the plant as to the Germans, was only one part of what was later known as "Operation Ossiavakim."

The result of this move was to reduce the morale of the remaining employees to a very low state. Most of those who did not live in the Soviet Sector of Berlin did not return to the plant. The Russian officers realized that their long-range program of goodwill had been defeated and saw their own positions endangered unless they did everything in their power to save the factory from complete dismantling.

In November 1946, upon the accidental death of Colonel Boldyr, Major Wildgrube was nominated as the new chief.

Gradually they succeeded in readjusting the personnel situation, locating new research people, and securing their cooperation. By mid-1947 the situation was again under good control with approximately the following plan of organization:

Management (Dr. Rudolf Bechmann; Dr. Hans Straehler, Mätzig)

Vacuum Tube Development
Amplifier and receiver tubes
Magnetic-field tubes
Tube technology
Picture-tube development and technology
Tube-testing department

Development and Experimental Production of Discharge Tubes
(Dr. Hans Straehler)
Stabilization development
Rectifier development
Experimental manufacture

- Construction
- Pumping
- Tube testing

Discharge lamps
- Electrode research
- Glass technique
- Spectral high-pressure lamp
- Mecuric-oxide high-pressure lamp
- Tube-testing department

Development of Electrical Measuring and Testing Equipment (Brandle)

- Oscillography
- Television
- Electron optics
- High-frequency and radio-testing equipment
- High-frequency measuring equipment
  - Preliminary development
  - Development for manufacturing
- Development and manufacture of components
  - Transformer and circuit equipment
  - Detectors
  - Resistors
  - Quartz-crystal oscillators

General Technology (Richard Magner)

- Metal-ceramic technique
- Chemical tube technology
  - Emission pastes, insulation pastes
  - Analytical chemistry
- Tungsten and molybdenum
  - Preparation of powders
  - Working and machining
- Materials testing; metallurgy, chemical manufacturing
- Hard metals

Manufacturing and Construction (Walter Klose)

- Manufacturing control
- Mechanical workshop, tool, parts, and equipment manufacture
- Tube manufacture
  - Research and development construction
  - Cathode manufacture
  - Grid manufacture
  - Glass working
  - Tube assembly
  - Pumping
  - Tube testing
  - X-ray tube manufacture
- Construction
  - Equipment construction
  - Tube and component construction
  - Tool and apparatus construction
  - Machine construction
  - Electric-oven construction
  - Records, design control, and blueprinting

Central Technical Office

Technical planning office
Work preparation center

Technical Information Division

Publications
Basic technology
Translations office

Technical Associates

Industrial workshop
Energy production
Buildings administration

Administration and Supply (Mätzig)

Financial division
- Bookkeeping
- Calculations
- Shipping office

Organization and inspection
Materials supply
- Purchasing
- Stockroom
- Transportation

Work assignment
Social care
Personnel division

Management Council

The complete organization apparently consisted of approximately seven departments, 22 divisions, and 72 subdivisions. In the above listings some of these designations have been rearranged for simplicity.

At this time there were estimated to be about 1850 employees, of whom about 875 were office employees.

On 1 January 1948 there was a reorganization of the plant, consisting of an administrative separation of the development and research section (designated Versuchswerk-Oberspreewerke) from the manufacturing section (to be called Fertigungswerk-Oberspreewerke).

The latter section was to be self-supporting and the former subsidized by Moscow.

A report issued near the time of the reorganization indicated a total staff of about 2200, of whom 85 were members of the technical staff, 1500 were ordinary workmen, and 615 were on the clerical and administrative force. The latter figures indicate a much better balanced group than the figures of mid-1947 and are probably more nearly correct.

The main features of the organization as of 10 January 1948 were said to be as follows:

German Company Management (Christian Gruner, Dr. Hans Straehler, Mätzig)

Research Work (Dr. Hans Straehler)

- Tubes
  - Amplifiers and magnetrons
  - Cathode-ray tubes
  - Stabilizers and rectifiers
  - Discharge lamps
  - Research workshop and construction
- Technical information division
  - Work planning
  - Control committee
- Electrical measuring and testing equipment
  - Oscillography and television
  - Testing and measuring equipment
  - H. F. Transformer Iron
  - Instrument construction and testing

Manufacturing plant

- Tube and construction elements
- Stabilizers and rectifiers
- Construction elements
- Tubes
- X-ray tubes

Industrial laboratory

- Ceramic
- Electroplating
- Analytic chemistry
- Physics

Wire manufacturing

- Chemical refining
- Metal working
- Instrument construction
- Machine and oven construction

Technical information

- Work planning
- Central control office

Business Management

- Financial divisions
- Supplies and transportation

Personnel, Safety, and Security Divisions

As of 1 January 1948, the control of the OSW was also changed over from the command of SMA to the SAG "Isolator." By this date it is reported that Dr. Bechmann and at least five of the department heads of the mid-1947 organization failed to return from leaves of absence. The result was to cripple seriously some of the fields of operation and to stop all further leave for German personnel.

In early 1948 the staff of technicians and skilled mechanics was said to number 150. The drafting of further personnel from the Russian Zone has been contemplated, but the Soviet authorities claim that the ultimate fate or disposition of the OSW must be definitely determined before such a step can be taken.

Although all German translators and interpreters at the OSW were replaced by Russians during the winter of 1947-48, the policy was reversed when the Russians received orders to return to the USSR before 28 March 1948. The German replacements were recruited under very attractive terms. These actions seem to agree with more recent reports that considerable numbers of Russian personnel are being evacuated from Germany and replaced with German personnel.

It is reported that, effective 1 January 1949, the name of the organization was changed from Oberspreewerke to "Werk fur Fernmeldewesen 'HF' (OSW), Zweigniederlassung der staatlichen Aktiengesellschaft 'Isolator'."

Since 1 December 1948, the Russian officials of the plant have been wearing mufti, and civilian titles such as manager and director have been substituted for military titles. This change in organization does not seem to indicate that the OSW is considered much less important than it was formerly. Operations appear to be continuing with a rather high level of activity.

II. PRODUCTION FIGURES

As indicated previously, there has recently been a separation of the manufacturing activities of the plant from the research and development activities. It is intended in this section of the discussion to consider the production from the manufacturing point of view, and to devote the following section to the research and development program.

The first part of the production picture concerns the numbers and types of items produced, followed by a general discussion of the production situation.

Information on estimated and actual production figures has been rather scarce and has been limited mostly to vacuum tubes. Division of the production items into five main groups appears to be the most convenient:

1. Electrovacuum and gas-discharge instruments
2. Radio-measuring instruments
3. Detectors
4. High-temperature furnaces
5. Refractory metals

The following is a list of what are apparently the principal production items under these headings (a complete list of all items to which reference has been made from any source is scheduled for preparation at a later date). The asterisks indicate items for which a lesser degree of certainty should be claimed, and the symbols used in the column headed "Tube No." are those most commonly used in referring to the tube, whether the symbols are of US, German, or USSR origin. 6AC70 and 6AG70 apparently indicate revised designs of 6AC7 and 6AG7, respectively.

Tube No.	Description	1947	1948*
A. Electrovacuum and gas-discharge instruments			
	1. Cathode-ray tubes		
3DP1	Polar coordinate, with central electrode	600	1000
5FP7	Magnetic focus and deflection	840	1000
2145	9-cm diameter	-	600
2146	12-cm diameter	-	150
	2. Metallic klystrons		
723A/B	20 mw, 3.1-3.4 cm reflex klystron	600	300
726A	3 watt, 9.9-10.9 cm klystron	1900*	1000
	3. Metal-ceramic tubes		
LD7	Metal-ceramic triode, 100 w, 50 cm	360	200
LD9	Metal-ceramic triode, 300 w, 9 cm	240	200
LD11	Metal-ceramic triode, 60 w, 10-100 cm	540	200
LD12	Metal-ceramic triode, 2 w, 9 cm	540	200
	4. Discharge tubes		
HB02000	High-pressure mercury lamps	80	120
-	Other high-pressure mercury lamps	400*	540
-	Neon lamps	-	460
-	Various spectrum lamps	-	600

Tube No.	Description	1947	1948*
5. Other vacuum tubes			
5D21	Tetrode radar modulator	960	
6AC7	TV amplifier pentode	20400	80000
6AC70	TV amplifier pentode	15600	
6AG7	Video power amplifier pentode	7200	20000
6AG70	Video power amplifier pentode	6000	
6J6	Twin triode	9600	2000
829B	Beam-power amplifier	(350)	1000
LK715A	Raytheon tube which was revised to make the 5D21		6000
OSW2332	Zero-slot magnetron	175*	
STV150/40	Stabilizer or rectifier	6000*	
Te5	Stabilizer or rectifier	16000*	
B. Radio-measuring instruments			
OSW2113	Thermal element for maintaining constant voltage. Nominal voltage 2 V+30% at 0.1-2.0 ma	7200	
OSW2183	Bolometer	600	-
-	Bolometric equipment, 3-10 cm		
-	Spectrum analysers, 3-10 cm		
-	Field-strength meters, 3-10 cm		
-	Tube wavemeters, 3-10 cm		
-	Precision wavemeters, 3-10 cm		
C. Detectors			
ED704	Crystal detector	5000*	
ED705	Crystal detector		
ED707	Crystal detector	-	-
D. High-temperature furnaces			
-	Conveyor furnace for 1200°C (100 x 1000 cm)	-	-
-	Double-tube furnace for 1200°C (100 x 1000 cm)	-	-
E. Refractory metals			
-	Tungsten wire of small diam.	600 km	-
-	Tungsten wire, 0.24-0.1 mm	250 km	-
-	Tungsten wire, 5-0.24 mm	120 kg	-
-	Molybdenum wire of small diam.	600 km	-
-	Molybdenum wire, crude types	175 km	-

Indications are that at least 200 different projects have been worked on from either the development or the production standpoint. Of these, approximately 10 percent (included in the above tabulation along with other items) has been in significantly heavy production.

A report commenting on production up to 18 April 1947 stated that 2500 klystrons for 9 and 3 cm, 5000 detectors, several hundred special detectors for millimeter waves (probably 8 mm), several hundred special oscillograph tubes, and several hundred blue-trace tubes had been produced. It is estimated that approximately 100,000 tubes of all kinds were produced during 1947 by the OSW factory.

Radical price reductions (up to 50 percent and more in some cases) are said to have occurred between January 1947 and January 1948 as the result of improved mass-production methods. The rate of rejection of tubes fell from 50 percent to 30 percent. The tubes all carried the OSW trademark and Russian nameplate data.

In late 1948 the OSW was suffering from a shortage of materials, especially of tungsten and molybdenum. Another difficulty lay in the fact that the OSW's wire shop was unable to prepare wires of the required delicacy for use in the tubes. The administration felt that these shortages would result in a general failure to meet production quotas.

Increasing difficulties were also encountered in 1948 in the production of electrical parts and other components, e.g., electrolytic condensers, resistors, and luminous phosphors. The situation regarding spectral analyzers was especially critical, and production deadlines had to be extended six weeks. Russian tubes for the analyzers were found to be inadequate (poor vacuum, insufficiently high gain); American-type tubes were to be procured from Moscow to replace those of Russian design.

The German management of the OSW felt that the 1948 production quotas could not be met unless the staff of 150 technicians and skilled mechanics was virtually doubled. The drafting of further personnel from the Russian zone was contemplated, but the Soviet authorities claimed that the ultimate fate or disposition of the OSW must be definitely determined before such a step could be taken.

On the whole, the production figures are very modest in size and do not indicate any outstanding achievements of the OSW. The reason is difficult to determine. These figures may indicate the output of a pilot plant or of an initial production plant rather than the total output. They may also be affected by sabotage by German workers, shortages of supplies, and other factors. (For example, there is strong indication of sabotage in the matter of tools used for drawing fine wire.)

Production figures include information available for the period through the end of 1948. Information on production plans for 1949 and future years will be discussed later under Part IV - Plans for the Future.

III. RESEARCH AND DEVELOPMENT PROGRAM

The research and development program constitutes the most important part of any discussion of an organization like the OSW. It is therefore especially fortunate that a large amount of material is available on this phase of the operations. The problem is chiefly one of selection and organization of items from an unusually large volume of jumbled and uncoordinated information. The quantity of material does not guarantee, however, that there will not be large and serious gaps in the picture.

Perhaps the most convenient approach to the subject is to follow an outline similar to that used in the plan of organization.

1. Cathode-ray Tubes and Iconoscopes

This field of development is receiving considerable attention at the OSW. Tubes of the following descriptions, OSW numbers, and other designations have been prominently mentioned by various sources:

OSW No.	Other Designation	Description
2066	R-23	20,000 km/s CRT
2068 A,B	E-210	---- CRT
2109	5FP7 (US)	Magnetic focus and deflection
2110	3DP1 (US)	Polar coordinate tube
2145	-	9-cm diameter
2146	-	12-cm diameter
2333	-	10-cm blue-trace projection tube

Indications are that types 2145 and 2146 may be intended for compact airborne equipment if large numbers are being made, but evidence thus far shows only a few completed.

Of the types listed, detailed specifications are available on the 2066, 2068A, and 2068B. Principal characteristics of these types are as follows:

	2066	2068A	2068B
General specifications:			
Screen color	blue-white	green	green
Deflection	double, electrostatic		
Cathode	oxide cathode, indirectly heated		
Heater voltage	6.3 v	6.3 v	6.3 v
Heater current	0.5 a	0.5 a	0.5 a
Anode voltage	20 kv	2 kv	4 kv
Lens voltage	3.2-4 kv	250 v	350 v
Screen-grid voltage	4 kv	2 kv	2 kv
Cathode current, max.	30μ (continuous current)	30μ	30μ
Vertical-plate voltage	650 v	100 v	200 v
Horizontal-plate voltage (probably for full-scale deflection)	650 v	100 v	200 v

The 2066 is probably for high-speed oscillographic or projection "Plan Position Indication" use, but large quantities are not indicated. The 2068A and 2068B are probably for radar equipment use.

The cathode-ray tubes under development at the OSW are said not to be for television purposes, at least not for television purposes according to our use of the term. One type of cathode-ray tube is a blue-trace projection tube for projecting cathode-ray images on a large screen in connection with the "Plan Position Indication" of radar signals. Some projects are under way for tubes with high writing speeds in the 10,000 to 50,000 kilometer-per-second range and even higher. Two projects for development of double-beam cathode-ray tubes are also mentioned, but no mention is made of the amount of progress.

Listed in the order of their military importance as classified by the Russian direction of OSW, the most important of the cathode-ray tubes are said to be the 3DP1, the 5FP7, and the OSW 2333.

The 3DP1 is a polar-coordinate tube which serves as indicator of altitude in aircraft. The Russians required OSW to produce this tube according to American standards and exterior dimensions. It differs essentially from the American type in some technical improvements in the anode system to reduce image distortion.

The 5FP7 serves as the tube in Panorama-vue equipment. (Note: This is probably the same as projection PPI.) It may be applied in aircraft and in ground stations. Depending on requirements it gives an image of the terrain beneath the aircraft (in aircraft equipment) or of the incoming aircraft (in ground stations). Technical data and exterior proportions of the tube are similar to those of the 3DP1. The requirement was that this tube could substitute for the original American RCA tube in American equipment. A divergence from the American tube consists in a plane screen developed by OSW, but this does not prevent the application of this tube in American equipment.

The OSW 2333 belongs to the television-type tubes, to which the Russians have been paying particular attention. (It may actually be the same one described previously as a blue-trace tube for screen projection.) The OSW 2333 is described in one report as being a 10-cm diameter blue-script projection tube magnifying to 1.5 m and using a 5FP7 cathode.

This tube is used for insertion in Panorama-vue sets. In order to facilitate the simultaneous viewing of the image for more observers the construction is provided with additional illumination and projection optics allowing projection on a second screen. The sequence of pictures is one picture per ten seconds (probably governed by the speed of antenna rotation). The American sets use luminescence-retentive phosphors for image improvement, but these procedures could not be applied to the OSW 2333 because the brightness of post-luminescence is not sufficient for projection of a panorama view by a screen of 100-mm diameter on a projection screen of 1.5-m diameter. For this reason the firm Telefunken incorporated the production of the tube into their blue-trace project. For better visibility of the screen spot, colored blue-violet (dark-trace tube) by the electron beam, an additional illumination was provided in connection with further projection developments. The speed of image fading may be controlled within certain limits by a heating of the screen carrier. Operational instructions for this tube differ from known television tubes because of special properties and the selected structure. (Note: No further amplifications of the special properties, structure, and developments mentioned above are available from the source. The situation described sounds similar to our problems with the large-size PP I program of five years ago.)

2. Fluorescent Materials

The main chemical for production of the fluorescent compounds is sulphide of iron, which had been supplied by the firm Merck at Darmstadt. After December 1947 the deliveries of raw material almost stopped.

Because of the lack of cadmium the OSW, as of October 1948, was unable to produce the white luminous type of screen which is essential for television. A green

luminous material (possibly zinc sulphide) is now being used which has Soviet approval. The Soviet supervisors are reported to have said that the color of the cathode-ray tubes is unimportant. (Note: Unimportant, apparently, for their own purposes.)

Some months previous to November 1948 the German technicians at the OSW asked the Soviets to provide fluorescent materials for the coating of the screens of cathode-ray tubes. In November 1948 there arrived (supposedly from Moscow) supplies of a yellow powder emanating a yellow-red light (thought to be zinc-cadmium sulphide) and a white powder emanating a blue light (thought to be zinc sulphide). (Note: These may be for long-persistence screens which are very necessary in certain tracking equipments.)

Recipes for the production of fluorescent compositions are given in the table which follows. Formulas, certain production details, color, and usage are shown.

Designation	Raw Material	Activator	Color	Glow Temperature	Persistence in Hours
N1 blue/1	ZnS	Silver $1x10^{-5}$ Nickel $1x10^{-7}$ Copper $1x10^{-5}$	light-blue	800°	1.5
N1 blue/2	ZnS	do	dark blue more violet	1100°	0.5
N1 blue/3	ZnS	do	deep-blue	900°	3
N1 green/1N	ZnS	Copper $1x10^{-7}$	green	400° 800° 1000°	1 0.5 2
N2 yellow/2	ZnS CdS	Silver Nickel	yellow	750°	1
N2 orange/1N	ZnS CdS	Copper	greenish	1100°	0.75
N3/yellow/1	ZnS ZnSe	Silver $5x10^{-5}$ Nickel $5x10^{-6}$	yellow	800°	1.5
N3 green/1	ZnS ZnSe	Nickel Copper	green	700°	1
N3 blue-white	ZnS ZnSe	Silver Nickel	light-blue	700°	1
N4 green	ZnO ZnS	-	green	800°	1
N5 green	$ZnSiO_3$	0.8-1% Manganese	green	1250°	5
N6 yellow	ZnO SiO_2	1.2-3% Manganese	yellow	1180°	4
N6 orange	ZnO SiO_2 (BeO)	1.2-3% Manganese	orange	1160°	4
Ng blue-white	MgO WO_3	-	blue-white	1050°	1.5
N2 green	ZnS CdS	Silver $5x10^{-5}$	green	850°	1

(At the time of preparation of the table, it was thought that the compositions were intended principally for ordinary cathode-ray-tube usage. However, the long-persistence characteristics indicated here will require a reconsideration of the probable ultimate use.)

3. Iconoscopes

As far back as June 1946, a copy of the RCA 1840 orthicon (a troublesome tube in the US) had been planned, but no further information on its progress is available at present. It is reported that as of 1 January 1949 a program for the development of iconoscopes was to be started by Walter Fricke, who studied the matter while he was at Siemens, Arnstadt.

4. Metallic Klystrons

All past indications are that the program for development and production of klystrons at OSW has never received as much emphasis as magnetrons, metal-ceramic tubes, cathode-ray tubes and a few other of the more prominent subjects. The following four projects are the only ones concerning klystrons which have come to attention:

OSW No.	Other Designation	Wavelength cm	Description
2009	726A	9.93-10.9	3-watt klystron
2013	723A/B	3.14-3.43	20-mw reflex klystron
2020	-	0.8	Reflecting klystron
2023	-	0.8	5-kv output klystron

(Indications from this table and elsewhere are that the Russians may be oversold on the 8-mm region and will later find it disappointing because of scattering.)

Of these four only the first two, which are copies of the American 723A/B and the 726A, appear to have been made in appreciable quantities. There is nothing unusual in their method of construction. The last reports available indicate high percentages of rejects and the attainment of only a small fraction of the rated power. It is apparent from the abnormally large number of failures that this factory has not mastered the necessary construction techniques, possibly because of lack of adequate equipment. Very little progress has been made and no known effort is being made to produce high-power klystrons.

In evaluating the situation, emphasis should be placed on the lack of high-power klystrons and the difficulties (similar to the early US troubles) with construction techniques.

5. Metal-ceramic Tubes

More activity has taken place in this field than any other except, perhaps, magnetrons. Metal-ceramic tubes are one of the most important and valuable achievements of the Bureau of Electrovacuum Technics, Scientific Technical Section (NTO) of MPSS (Ministry of Communications Industry) in Berlin.

In 1940 work began in Germany on developing air-tight ceramics and on the technology of soldering ceramics to iron-nickel alloys.

This new technology allowed a series of new types to be made, so-called flat electrodes or "washer" tubes, which offer at present a complete design of triode systems for the decimeter- and centimeter-wave bands. It must be observed that the first flat-electrode tubes in a glass form were applied in the USSR in 1937-1939. Later tubes of this type known as "lighthouse tubes" appeared in glass form in America (such as tube GL 446). The Russians call these tubes MAYAK, a literal translation of "lighthouse."

But metal-ceramic tubes have several great advantages over glass ones. The most important of these are:

(a) The possibility of obtaining comparatively easily very great accuracy in the most important geometric dimensions and consequently identical parameters of the tubes. The inter-electrode distances in tubes of these wave bands is approximately 0.1 to 0.2 mm and the ceramic parts can be mechanically produced quite easily with an accuracy of 0.05 mm. It is very difficult to obtain such accuracy with the glass form.

(b) The mechanical durability of the tubes is considerably higher than that of glass ones.

(c) Metal-ceramic tubes are less thermo-sensitive.

(d) Dielectric losses in ceramics are very small.

(e) It may be assumed that mass-production of ceramic tubes would be considerably cheaper than that of glass tubes for the centimeter- and decimeter-wave band.

The fundamental stages of the development of metal-ceramic tubes took place between 1941 and 1944. The technology of these valves has been fully reestablished and partly revised by the Bureau of Electrovacuum Technics (BET). The development of metal-ceramic tubes included the following basic stages:

(a) Development of air-tight ceramics.

(b) Development of the technology and construction for soldering ceramics to metal (iron-nickel, similar to ferniko according to indications).

(c) Development of getter not requiring pulverization and working at a low temperature. (Note: Procedure in US is usually to bake and pump extremely hard without the use of a getter.)

(d) Developing the design and technology of these tubes.

(e) Developing a method of testing and using metal-ceramic tubes.

Apart from reestablishing the technological process of metal-ceramic tubes from the experience of the Telefunken Co., BET has thoroughly revised the design of the tubes, viz. has substituted the application of soft iron for that of the less common nickel-iron. This is very important, since there is a shortage of nickel-iron, and it is not produced in the USSR. It is reported that some supplies of scarce metals have been brought into the zone personally by procurement personnel of the OSW.

Experiments carried out with tubes produced according to the technology of BET but with the use of iron instead of nickel-iron showed that the quality of the tubes was not impaired.

The life of the metal-ceramic tubes produced by BET on the basis of these experiments, is not less than 500 hours. The percentage of serviceable tubes in mass production is 50 percent.

Of the several types of metal-ceramic tubes for which any appreciable production is indicated, the following are particularly prominent:

OSW No.	Other Desig.	Wavelength cm	Power	Approx. Efficiency	Description
-	LD7	11-50	100 w	29.6% at 20 cm	Decimeter triode
-	LD9	15(minimum)	40 w	15.2% at 18 cm	Decimeter triode
2166	LD11	11-100	60 w	-	Decimeter triode
2004	LD12	9-100	2 w	2.5% at 9 cm	Decimeter triode
2005	LG11	15	-	-	Decimeter diode
2008	LD70	9-20	11 w	-	Decimeter triode

(Note: The 2.5% efficiency for the LD12 appears extremely low, but may be correct as indicated in the data, since it occurs at the limiting wavelength.)

a. Description of types

Tube LD12 - Use: Externally excited decimeter - wave frequency doubler
Design: metal-ceramic with fins
Heater: 12.6 volts; 0.8 amp
Cathode: oxide, with indirect heating
Limiting values:

Limiting wavelength	9-100 cm
Anode dissipation	P_a max = 80 watts
Grid dissipation	P_{gl} max = 2 watts
Anode voltage	V_a max = 800 volts
Cold anode voltage	V_{aL} = 1000 volts
Anode voltage for pulse operation (t = 5 microsec)	V_a = 2000 volts
Grid voltage for pulse operation	V_{gl}max = +50 -150 volts
Effective cathode current	I_k eff = 150 ma
Cathode current for pulse operation	I_k max = 1.5 amp
Anode temperature	T_a = 200°C

(with air cooling at approximately 6 liters per minute)

Useful power of 2.0 watts when:
Wavelength = 9 cm
Anode voltage = 800 v
Cathode current = 100 ma
Grid bias = -5.5 v (approx.)
Anode temperature = 200°C

The tube is useful for amplification purposes in reception of high frequencies, and also as an amplifier in the decimeter-wave band.

When the type LD12 tube is being used as an oscillator with self-excitation, the regeneration is effected outside the tube in an external circuit.

The development of this type of metal-ceramic triode has made it possible to construct a continuously operating wide-band generator operating from 8 to 24 cm.

The possibility of a smooth change of wavelength over the whole band with a good output opens up great possibilities for the use of such a generator. A generator of this type is of great use as a test oscillator in the development of various radar apparatus and instruments and also in a whole range of physical experiments in the decimeter- and centimeter-wave bands.

The metal-ceramic triode is used as the oscillator for the wide wave-band generator. The tube is constructed with a flat-electrode system inside the tube and coaxially arranged low-inductive leads from the internal electrodes.

In construction the tube is planned as a grounded-grid triode. Internally the anode-cathode tube capacity is insufficient for the realization of optimum regeneration for the working of the tube in a self-excited generator. For this reason, when the tube is in operation, further regeneration of the anode-grid and grid-cathode elements is used in the generator. The circuit is the usual one for tubes with grounded grid. There are two oscillator elements; an anode-grid and a grid-cathode element. The first of these is the one from which the output of high-frequency power takes place.

Segments of coaxial lines are used as elements. The external line is the anode-grid element, the internal one is the grid-cathode element. Both elements have moveable short-circuiting pistons, which make it possible to alter the wavelength generated over the whole band. Between the elements there is a common metal wall. In order to afford supplementary regeneration longitudinal slits are made in the wall. Through these slits from the cavity of the anode-grid element into the cavity of the grid-cathode element are inserted metal stems, by means of which a capacitative regeneration takes place. On moving the pistons adjusting the elements the regeneration stems are also

moved. This is essential in order that the regeneration should remain in the required phase over the whole band. On the outer casing of the generator there is a scale, which enables the operator to move the pistons adjusting the elements to the necessary position for the generation of any wavelength of the band covered. (Note: This has been copied from the US. The whole problem is mechanical coupling of the several moving parts so as to operate on a single knob.)

One use to which the wide wave-band generator may be put is the testing of metalloceramic triodes intended for work over a wide band. For this purpose, a power load is connected to the generator with a special measuring lamp (probably neon) and a photocell. (Note: This is a very elementary method first used in the US but had been replaced by better methods by 1941.)

The basic technical data and OSW claims for the wide-band generator are as follows:

Ranges: 8 to 15.5 cm and 16 to 24 cm.

With anode voltage at 800 volts and cathode current at 100 ma, high frequency power from 2 to 10 watts may be obtained.

A generator with such a wide wave-band in the centimeter and lower decimeter bands has never existed before. (Note: Such has certainly existed in the US, if not in Germany. If the first in Germany, or even if believed the first, this point is significant.)

Tube LD11 - This tube differs from the LD12 in design in that the stems leading from the cathode to the anode-grid area are inside the tube, to effect a capacitative regeneration. The arrangement constitutes a built-in leak around the grid for use as an oscillator only.

Some of the principal characteristics of the tube are:

Heater voltage	12.6 v
Heater current	0.75 - 0.88 amp
Minimum wavelength	11 cm
Anode voltage	800 v
Cathode current	100 ma

A test set, type 6431, has been designed to test metal-ceramic triodes type LD11 for generation of oscillations. The set is formed from a system of two oscillating circuit elements - the anode-grid and the grid-cathode with the tube under test installed in the system.

A test set, type 6432, has also been designed to test type LD12 tubes in serial production.

Tube LD9 - Metalloceramic triode for operation as self-excited oscillator (CW operation or pulsed modulation), and also for amplification (direct amplification and doubling of frequency). (Note: It might be designated an "all purpose" tube.)

Construction: metalloceramic with radiator on anode
Vibration testing: 5 g (at amplitude of 0.55 mm, f = 50 cps)
(Note: Indicates weak mechanical structure inasmuch as our tubes withstand 100 g)
Statistical data measured with radiator screwed to anode
Cathode: oxide, with indirect heating
Heater voltage: 12.6 v (underheating to 11.3 permissible but without guarantee of effect on emission)
Heater current: 1.1 amp
Minimum wavelength: 15 cm
Anode voltage (constant operation): 2500 v, max

Cathode current, class "B" operation without modulation — 225 ma, max
Cathode current with anode modulation — 190 ma, max
Useful power of 40 watts (approx.) when:

Wavelength	=	18 cm
Heater voltage	=	12.6 v
Anode voltage	=	1500 v
Current	=	175 ma

Tube LD-7. - Metal-ceramic triode for pulsed operation with self-excitation.
Metal-ceramic design with anode fins
Vibration test: 5 g (at amplitude of 0.55 mm, f = 50 cps)
Statistical data are measured with radiator screwed to anode
Heater: 12.6 volts; 1.1 amp
Cathode: oxide, with indirect heating
Limiting wavelength: min = 11 cm on pulse work.
min = 17 cm on cw.
Anode dissipation: P_a max = 350 watts
Anode voltage with continuous operation: V_a max = 2500 volts
Peak anode voltage (at t = 10μs): 9000 volts
Useful power P = 20 kw at:
Anode voltage = 9000 v
Wavelength = 20 cm
Current = 7.5 amp

b. Other metal-ceramic tubes

The following metal ceramic tubes have come to attention since December 1948.

The metal-ceramic diode OSW type 2432 is a recent development of the earlier Telefunken type LG11. This diode is used as a detector for the 30- to 80-cm range.

The OSW type 2540 tube is a metal-ceramic triode intended for operation at shorter wavelengths than the previously described LD12. The type LD12 has an output of about 2 watts but is limited to a wavelength of about 8 cm. With the type 2540 it has for the first time been possible to produce suitable operation in the 7-cm region with an output of 100 to 500 mw. (Note: It is possible that ultimate application of this tube may be for microwave relay links.)

A large amount of detailed technical information, including diagrams and illustrations, is available for the 2432 and the 2540, but the amount is such as to make inclusion in the present report impractical.

6. Ceramics Soldering Techniques

By ceramics for soldering is meant ceramics suitable, after the necessary treatment, for fusing with metallic parts. It is used in constructions for which the union of the metal with ceramic must be effected by fusing, as in metalloceramic tubes, detectors, etc.

Composition: 85% talc
12% kaolin
4% zirconium oxide
2% feldspar
All materials must be dry (not damp)
Compressed to one-sixth volume and baked
Fusion point 1350°-1380°C

For better flow (covering power) of the solder onto the molybdenum covering, a nickel layer is baked on.

A detailed report on successes in the technique of soldering metalloceramics has been prepared in which the temperature interval of compact tempering of the ceramic, resistance to bending, electrical properties, and other characteristics were investigated.

As a result a new ceramic:

92 gm talc
5.5 gm kaolin
2.8 gm boric oxide

with a softening temperature of 1310 to 1330°C was proposed in place of the composition previously given.

Silver-phosphorus alloy is composed of 80 percent copper, 15 percent silver, and 5 percent phosphorus. It is also used for soldering metal-ceramic tubes. When using other solders it is necessary to employ borax as a flux. Particles of this remain around the joint and are harmful to the apparatus. Silver-phosphorus alloy needs no borax and therefore no traces of flux remain. The moment that it begins to melt, it flows quickly and evenly over the prepared surfaces while the phosphorus acts as an excellent reducing agent. As a result, the soldered surfaces are closely and solidly joined with a thin cupro-silver film. Furthermore, this alloy permits high-speed soldering at temperatures between 700° and 1400°C. The experiments to determine the properties of the alloy were made on actual parts used in electro-vacuum production.

7. Magnetrons

Since radar is a vital and important part of present miliary programs and since magnetrons are a vital link in a microwave radar system, this subject is one of the most important with which the OSW is concerned. The ability of the USSR to produce magnetrons is a measure of its capabilities to produce and use centimeter- and decimeter-wavelength radar equipment, which in turn controls in part its ability to counter or neutralize strategic or tactical bombing missions against the Soviet Union.

The following paragraphs (together with Fig. I) summarizing the magnetron situation at OSW as of May, 1948, are quoted from the Intelligence Research Project No. 4301 by the Military Intelligence Service, WDGS:

> "The OSW program includes magnetrons operating from 0.9 to 150.0 cm in wavelength, with a large gap between 10 cm and 100 cm. This gap is partially filled by other types of tubes. In particular, there is one project for development of a 0.9-cm magnetron delivering 500 watts; one project for magnetrons covering the range 1.5 to 10.0 cm, in two models overlapping at 2.8 to 3.0 cm; another project for two models covering the range from 1.0 to 9.4 cm, with an overlap from 2.0 to 3.0 cm (both this and the preceding project being the low-powered 'nullschlitz' or zero-slot magnetron, and having a probable manufacture of less than 100 to date); another continuously tunable 'nullschlitz' magnetron for the range 2.5 to 7.6 cm, in which the early versions had gaps in the spectrum; five projects for 3.2-cm magnetrons, running about 30- to 60-kw power output, of which at least two are attempts to copy U. S. tubes, and in none of which is there any indication of significant production; and three final projects including a 3.8-cm, 1/2-watt magnetron; a 10-cm 1000-kw magnetron; and a 100- to 150-cm, 500-kw magnetron.
>
> "Also of considerable interest at this time because of our own work on a similar tube is a report that Laboratory 115 is experimenting with a 'Haban' (Prof. Haban formerly worked for the OSW but reportedly was sent to the USSR in October, 1946) tube 'fitted with an outside cathode and an inside anode, without slits.' This type of construction

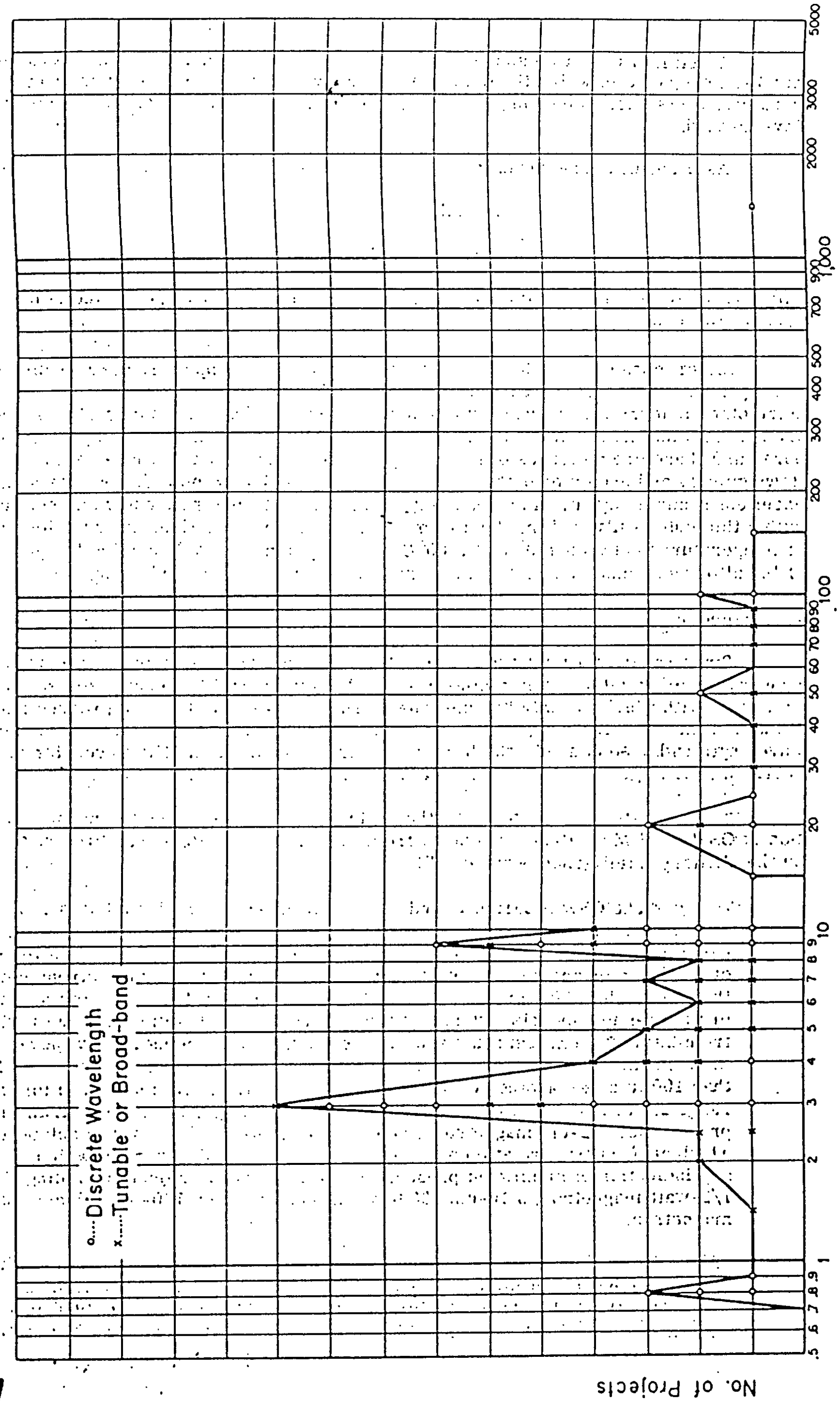

Fig. 1. Wavelength Coverage of OSW Transmitting Tubes.

is especially useful at millimeter frequencies when scaling down of conventional dimensions results in too small a cathode, hence too little power."

Relatively few types of magnetrons appear to have been produced by the OSW in appreciable quantities. Of approximately 20 various types to which reference has been made at one time or another, only two appear to have had any appreciable production up to recent date. These are the OSW No. 1200, Haban-tube (with anode inside cathode) and the 2332 slotless magnetron. The importance of these two tubes justifies detailed descriptions of each in a later part of the section on magnetrons.

In the early stages of planning of the magnetron development program, a conference of the technical staff was held on 28 August 1947 to discuss development of magnetrons in the 0.8 to 12 cm range with power output of more than 100 mw. The following important information on decisions reached will serve as a guide to a more detailed discussion of a few of the magnetrons:

Wavelength from 8 to 12 cm - a continually tuning magnetron is to be used in conjunction with a transmitter developed by one of the staff.

Fixed wavelength of 6 cm - the slotless magnetron OSW 2332 Type A is to be used. If, however, a 6-cm tube is required for direct fitting into a transmitter, a new tube must be developed. (Note: The phrase "direct fitting" seems to indicate communication or aircraft landing.)

Wavelength from 2 to 4 cm - the slotless magnetron OSW 2332 Type A or a new type of tube still in the development stage is to be used. If a tube with a fixed wavelength from 2 to 4 cm is required for direct fitting into a transmitter, it should be developed.

Fixed wavelength of 1 cm - the 8-slot magnetron, still in the development stage, operating on a wavelength from 0.8 to 3 cm could be used. (It should be noted here that more recent information on this development has become available and will be discussed later.)

During the conference, the question of replacing American tubes by other tubes already available at the OSW or tubes still to be developed was discussed. The suggestion was made that it would be easier to use American tubes for these transmitters. Such tubes could be made available from stocks held in Russia, which would be preferable to developing new types at the OSW.

The first tube mentioned in the above list, for the 8- to 12-cm wavelength region, is not identifiable by number for further description on the basis of present information.

At the fixed wavelength of 6 cm and in the 2- to 4-cm region, the slotless magnetron OSW 2332 Type A is prominently mentioned.

There is a large amount of detailed construction and testing information concerning both OSW 2332 Types A and B. Some of the details which should be of more general interest are reproduced here:

The external measurements and the majority of internal details are identical in both 2332A and 2332B types of magnetron.

The magnetron consists of two basic constructional parts, the cathode system and the anode system with welded glass cylinders.

The cathode system is welded through the glass into the anode and is fixed strictly concentrically along the axis of the anode cylinder. The cathode in the form of a straight extended filament of tungsten wire is welded at each end to molybdenum cathode holders.

A matter of great importance is the exact centering of the cathode in relation to the anode. The centering may be attained by the accurate construction of the parts and by the use of a special mandrel on welding; furthermore for the same purpose in magnetron type A two ceramic insulators of "ergan" or ammonium oxide are used. Magnetron type B, having a shorter cathode, has no insulators and the centering is attained solely by accuracy of assembly and welding. After a long series of experiments it was found necessary to give up the idea of using insulators in type B, as supplementary losses caused by the presence of the insulator with wavelengths shorter than 3 cm become relatively large.

The anode, of cylindrical form, is drawn of electrolytic vacuum-fused copper. The internal diameter of the anode on type A is 3.6 mm and on type B is 2.5 mm.

For the better removal of heat and for the provision of mechanical durability the anode is quite large (external diameter 10 mm). Pole pieces of soft carbonless iron are soldered to the anode to form a unit. To the pole pieces on the side are soldered small "ferniko" glass containers, to which are soldered glass cylinders. Thus the anode, together with the pole pieces and the glass tubes soldered to both blocks, forms a vacuum-tight unit into which the cathode system is welded.

The evacuation of the magnetrons is carried out by means of a stem introduced into the flat part of the glass tube.

For assuring reliable contacts, prevention of corrosion, and reduction of losses at high frequency, all external current-bearing surfaces are silvered.

The manufacture of the 2332 magnetron is relatively simple and does not present any particular difficulties. Manufacturing procedure as with most radio tubes may be divided into the following basic stages:

Manufacture of parts

Successive assembly of and work on the various sections

Assembly of tube

Welding and insertion of stem

Evacuation

Testing

The two basic sections, the cathode system and the anode with pole pieces and glass tubes, are prepared separately until the final assembly of the magnetrons for welding.

In the manufacture of the cathode system all the metal parts are produced by ordinary mechanical means (turning and fitting operations). The spring for stretching the cathode is wound into a spiral from sintered tungsten wire and is tempered in inert gas at 1300°C. It is important that the strength of each spring be fixed, therefore after tempering, the strength of each spring is tested.

Before the assembly into sections all copper and nickel parts are cleaned of grease in trichlorethylene, and molybdenum parts are cleaned of oxides by electrolytic dipping. The joining of the parts on assembly of the sections of the cathode system is effected by spot and butt electric welding, and hydrogen is blown over to prevent oxidation at the points of welding. The welding of the cathode to the molybdenum holder is done through a layer of foil with the use of a special mandrel. (The degreasing and foil brazing are considered to be good modern techniques.)

The anode section, consisting of a copper anode with iron pole pieces, "ferniko" cases and glass cylinders soldered to it, is the exterior casing of the magnetron; therefore the joints between all the elements of the anode section must be vacuum-tight. The manufacture of the anode system consists of the following successive basic operations:

Manufacture of the anode, pole pieces, and "ferniko" glass containers (turning operations).

Soldering of pole pieces (iron) with the "ferniko" cases by copper solder.

Soldering of anode (copper) with the pole pieces (iron) by silver solder (cupro-silver at eutectic point).

Final mechanical treatment of soldered section. Drilling of internal aperture of anode, external and internal shaping and polishing.

Soldering of glass cylinders to the "ferniko" glass containers.

The vacuum-tight soldering operations are very important; they may be carried out in two ways:

By soldering in a hydrogen furnace or by soldering in a vacuum high-frequency furnace.

The first method -- soldering in hydrogen furnaces -- is more suitable in manufacture but gives a greater percentage of wastage in flow.

The second method -- soldering in vacuum -- gives a better quality of soldering and negligible wastage in flow, but is considerably less convenient in manufacture.

Soldering in the hydrogen flame is carried out as follows:

The pole pieces and "ferniko" cases, already prepared by turning on a lathe, are carefully cleaned of grease and are assembled. At the point of contact of the parts a small ring of copper wire solder is placed. After being assembled thus the section is placed in the furnace with hydrogen flow and the temperature raised to 1120°C.

Simultaneously with this soldering there is carried out the "high-temperature" silvering of the other flat surface of the iron pole-pieces. As silver solder does not flow well on iron, for the subsequent soldering of the pole pieces with the copper anode a preliminary silvering of the iron at the point of soldering takes place. The method of "high-temperature" soldering worked out in the Bureau of Electrovacuum Technics is widely used in the manufacture of klystrons and metalloceramic tubes.

Briefly, this method is as follows: To the section of the surface of the iron part to be silvered a nickel paste is applied with a brush; the paste consists of very fine nickel powder mixed with a cellulose varnish. Afterwards the paste is dried, the binding is burned off and the part is heated in a hydrogen furnace up to 1120°C, during which sintering of the nickel powder to the iron surface takes place. Silver, on fusing, flows

very well over a surface coated with nickel in this way. A small piece of silver, generally in wire form, is fixed to the pasted surface before sintering. On heating in the hydrogen furnace, fusing of the silver takes place simultaneously with the sintering of the powder. Thus the silver flows over all the pasted surface forming a smooth, very firm, silver coating. In this way silvering of the other end of the pole pieces takes place simultaneously with the first soldering of the pole pieces and "ferniko" cases, as a preliminary operation for the subsequent soldering with the copper anode. The soldering of the anode with the pole pieces is carried out by a copper-silver eutectic process in approximately the same way as the soldering of the pole pieces with the "ferniko" cases described above. The parts are assembled for soldering and are fixed together by means of supplementary ceramic mandrels and are bound together with molybdenum wire. A number of such assembled sections (20 to 30, depending on the capacity of the furnace) are placed in the hydrogen furnace and are heated to 810 to 830°C; the eutectic then fuses and soldering takes place. (Note: This procedure sounds parallel to that used in the US.)

After soldering, the anode section is brought to the required measurements according to the drawing and the internal aperture of the anode is drilled. After that the part is cleaned of grease and the glass cylinders are fused to the "ferniko" cases. Fusing of the glass was done by hand by means of a table burner, but this fusing may also be carried out on a horizontal glass-blowing machine.

After the fusing of the glass the metallic surfaces are cleaned of oxide by mechanical methods and by dipping, after which the anode section is to be joined up with the cathode section.

The cathode and anode systems are assembled and fixed in a special mandrel, in which also the final welding takes place. The significance of the mandrel is to secure the accurate centering of the cathode system in relation to the anode. After welding and insertion of the stem the magnetron is heated in a muffle furnace for the removal of stresses in the glass; the magnetron is first filled with nitrogen to prevent the oxidation of the internal magnetic parts.

After this the magnetrons are vacuum-tested and are evacuated.

The evacuation is done on an ordinary high-vacuum pump, several magnetrons at a time. The evacuating process and cathode-formation are, in principle, the same as for normal diodes with tungsten cathode.

After the evacuating process, contact ferrules or caps are soldered by tin to the "ferniko" cases at the point of fusion with the glass and protective cases are screwed on to the pole pieces.

For the manufacture of magnetrons 2332 comparatively little special equipment is called for. All the parts are manufactured with universal turning and joining equipment. For small-series production no more than two special mandrels had to be manufactured.

Little information has been available on the production of this type tube except that relatively few are known to have been completed thus far.

8. The OSW No. 1200 "Haban" Tube

Compared with the slotless magnetron described above, little information is available concerning the Haban tube. The following is quoted from a report dated 11 January 1948:

"This tube belongs to the 'magnet resonance receivers' (Magnet-Resonanz-Empfang). Suitable results were first obtained with this tube in the OSW. The plan for the development of such a tube originates with Dr. Haban. (Note: In various connections the spellings "Haban" and "Habann" are both used). The first experimental tube was produced in the years 1945-46, without, however, obtaining completely clear-cut measurements of nominal values. After the departure of Dr. Haban to Russia in October 1946 the development stopped until the early part of 1947. In May 1947 further experimental construction was again started on the two construction plans of the tube designated as the SKR87 and SKR90. These two construction plans, designated as Haban Tube Construction I (SKR87) and Haban Tube Construction II (SKR90), are differentiated by the fact that Construction I is prepared for one-sided and Construction II for two-sided tunability. The construction of both tubes is characterized by the fact that a suitable, short, directly heated cathode is situated eccentrically between two outer anode - and inner cylinders, and the electron stream passes in between the cylinders in a way determined by the applied anode voltage and the existing magnetic field, according to the corresponding literature of Dr. Haban.

"The development specifications for these tubes, that is, for the development of experimental models, are contained in the periodical supplement of 10 April 1947. Preliminary technical specifications of the experimental model are according to the system of Dr. Haban. The custodian of this tube is the agent of the SMA-Engineer Afanasyev.

"Most of the experimental tubes constructed up until now show leakage with static operation of the pump.....

"The construction specifications of both the completed tubes SKR87 and SKR90, as well as the tuning control SKG121.20, do not yet display the conditions which will permit them to fulfill the requirements ordered by the Russians.

"The whole project must as yet be considered in the development stage."

9. Slotted magnetron

A recently mentioned tube on which information is available as of December 1948 is an 8-slot magnetron known as type OSW 2585. (This is apparently the tube to which reference was made in developments for a fixed wavelength of 1 cm.) No production information is available but the following description has been selected from a rather large volume of material on the subject.

"In the OSW the triode OSW 2004 was developed for the decimeter-wave region down to 8 cm. For the wavelengths from 1.5 to 10 cm the two tubes OSW 2532A and 2532B were produced. They are unslotted magnetrons. At 1.5 cm they still give an output of from 20 to 50 milliwatts. However, the handling required for these tubes is rather complicated so that a test oscillator supplied with them is not simple to use. Alternate tubes which are simpler to adjust are being sought. One alternate tube at the long wavelength end of the centimeter-wave region is the triode OSW 2540. In normal operation it reaches 7 cm, but perhaps in the case of properly designed oscillators, it can be driven down to 6 cm. For the region below this down to 3 cm several slotted magnetrons have been developed by Telefunken in Germany. To these a parallel wire or waveguide is coupled inductively or capacitively. These tubes are the RD2Mh which is tunable from 5.5 to 7.5 cm and the RD2Mg which is tunable from 3.1 to 3.3 cm. The oscillating circuit of these tubes is, as already mentioned, a parallel waveguide which is driven capacitively through the anode system. These tubes are simpler to handle than the zero-slot tubes. In a closely connected further development of these tubes the anode system is not in a waveguide but in a waveguide cavity which is tunable. In this way the radiation damping is reduced and it is hoped that still shorter wavelengths can be reached with this tube if the capacity of the anode system is reduced.

"The purpose of the task consists first of all in clarifying the question whether this is possible and if so to build a trial tube which will reach from 3 cm down to a 1-cm limit. This should be tried first with an 8-slot anode although it was earlier determined that below 2 cm there should be a change-over to a 6- or 4-slot anode system to reduce capacity. The tubes should furnish an output of at least 50 mw. In the following these experiments and their significance are discussed.

"The oscillation mechanism of the multiple-slot magnetron has already been thoroughly described in the literature. However, reference is made to the fundamental work of Posthumus, and of Herringer and Hulster in which experimental material is compared to the work of Posthumus.

"The electrode of this magnetron consists of a cylindrical cathode whose axis is the same as that of a multiple-slot cylindrical anode. The electric field in the slots between the segments of the anode are so constituted that in adjacent slots the field has a phase displacement of 180°. This so-called push-pull oscillation can be thought of as consisting of two fields rotating in opposite directions. This can be seen if one imagines an observer, at the cathode, with a field of vision so small that at most he can see only one slot. If this observer now turns in any direction so fast that he continually sees the next slot, then when the time for a half-period has just passed, he will see, in every slot which has come within his vision, the same field. He has the impression that the field rotates with him.

"Of the electronic phenomena in the magnetron one has the following picture: On account of the magnetic field, the electrons maintain a rotating motion around the cathode. The speed of rotation close to the anode is exactly as great as that of the rotational field. According to its position, an electron will be either in a decelerating or accelerating slot field. By means of the magnetic field, however, sorting takes place. All those electrons whose phase is such that they are in a decelerating slot field will not be permitted to go to the anode. An observer turning with the same angular velocity would see a stellate electron distribution in which the number of serrations equals half the number of slots. The rotating electron cluster, because of its electrostatic induction current in the anode segments, maintains the oscillations. The electrons are continually decelerated by the alternating field, i.e., they lose kinetic energy to the alternating field. From the static field they acquire just sufficient energy to maintain correctly the speed of rotation. Thus they come closer and closer to the anode, until finally, on bombardment, the remaining kinetic energy is changed to heat.

"The simple reflections hold only for the time-average value of electron motion. Individual electrons, on the other hand, maintain small, rapid oscillations. Under certain conditions these oscillations become very small. Then the over-all efficiency is at its optimum. This optimum depends largely on the direct-current voltage of the anode. One may expect that because of this simple exposition, calculation of the optimal anode potential has led to relatively exact values. Such a calculation was made by Posthumus. As follows from the works of Herringer and Hulster the calculated values coincide well with experiment, provided the diameter of the cathode is small with respect to the anode. Posthumus made his calculations for such cases.

"For greater cathode diameters the calculations have been expanded by L. Oertel in one of the OSW research sections."

10. Discharge lamps

Two low-pressure discharge lamps are the types OSW 2498 (xenon) and OSW 2578 (krypton), intended to be operated by the discharge of a condenser bank through them. The lamps have the following specifications:

Maximum light intensity	90,000,000 lumens
Light output	30-35 lumens/watt
Maximum single discharge energy	10,000 joules
Maximum pulse repetition frequency	15/min
Life	5000 pulses
Pulse length	1/500 sec) with 5500 v
Pulse power	5000 kw) and 700 μf

Lamps are tested after they have been stored not less than 15 days. On testing, the lamp is considered satisfactory if it operates correctly for 100 pulses. The limitation to 100 pulses for testing emphasizes the short life of the tubes. They apparently are intended for aerial photography or some type of infrared radar use, but the concentration on high energy per pulse and low number of pulses would seem to favor their use for photographic purposes.

Super-high-pressure mercury lamps types 2452 and 2525 with improved color have been developed. The following specifications are stated:

	Type 2452	Type 2525
Power used	500 w	2000 w
Type of current	DC and AC	DC
Voltage	DC, 100 v; AC, 200 v	100 v
Lamp voltage	70-90 v	50-60 v
Working current	5.6-7.9 amp	30-45 amp
Red radiation, approx.	8-10%	12-13%
Diam. of bulb, approx.	26 mm	45-50 mm
Length, approx.	145 mm	320 mm
Max. breadth, approx.	48 mm	55 mm

A request was made in February 1948 to hasten the supply of the type 2452 and 2525 lamps. (Note: It cannot be easily determined whether these lamps are for IR radar, aircraft reconnaissance photography, or other use.)

11. Other Vacuum Tubes

Evidence from several sources points strongly to the fact that the OSW has concentrated its greatest attention upon a relatively small group of tubes. Following are the OSW and other designations of these tubes, together with the amounts on hand and about to be accepted at the time of the report:

OSW No.	Other Designation	Quantity
2190	6AC7	5872
2192	6AG7	1770
2025	6J6	1958
2026	829B	274
2027	5D21	238
2109	5FP7	170
2110	3DP1	145
2013	723 A/B	200
2008	LD7	97
2006	LD9	135
2166	LD11	102
2004	LD12	35

Another very important list is that of tubes described in the order of their importance to military purposes, as classified by the Russian direction of OSW. These tubes

in the order of decreasing importance are the 3DP1 (altimeter range-scope on SCR 584 used this), 5FP7 (radar indicator), OSW 2333 (this number may be in error, perhaps 2332 at X-band and possibly at 6 cm), 5D21 (radar modulator; saves only space; more important in airborne; could use high-voltage triode instead), 6J6 (twin-triode), and the 6AC7, 6AG7, and 829B (standard types).

This group (except for the OSW 2333) constitutes a particular project of the OSW called the "seven-type program." It deals with cathode-ray tubes, which could be used as television tubes (but are more probably for radar exclusively) and with amplifiers suitable for various applications. The tubes are all copies of given American tubes.

Of those listed all except the 6AC7, 6AG7, 6J6, 829B, and 5D21 have been discussed previously. The following paragraphs contain quoted information on the descriptions and some of the manufacturing problems and applications of these tubes. In most places where the statements are erroneous or misleading, parenthetical notes of qualification have been added.

"The 6AC7 tube is a high-frequency pentode used in the first broad wave-band amplification stages. Apart from its other applications, there is a large demand for it in television. As a result, work in connection with the mass production of these tubes has been undertaken, with special reference to the conditions of production in the USSR.

"The tube produced is a revised model of the well-known American tube. It has the same name but differs from it only in outward appearance. The American tube is in metal form with the standard "lower stem" pinch. The lack of the necessary equipment in the laboratory did not allow an exact copy to be made, although its construction, parameters and field of application comply with the use of the metal form. But on the other hand, a prospective valuation of the standards of quality of radio-tube production shows advantages of the glass form which has had to be adopted. In the first place, the production of metal tubes in the USSR is fraught with a series of difficulties caused, for example, by the weakness of the vacuum-technology factories and the fact that the specialized equipment is worn out and requires either restoration or complete replacement. In the past several attempts have been made in the factories to deviate from the metal form of tubes and introduce the equivalent glass envelopes. In the second place, all the radio tube factories are not capable of producing metal tubes similar to the American ones and this affects the question of mass production. In the third place, the radio-tube industry has not yet adopted the production technique of flat stems and even the comparatively recent constructions have been based on the use of the old round stem, which impairs the quality of the tubes from the point of view of their high-frequency characteristics.

"On the other hand, if account is taken of the fact that small variations of the parameters of the tubes must be obtained when required, the inadequacy of the flat form of tube becomes very serious. Therefore two forms of the 6AC7 tube were designed. The first flat form was completed in 1946, and the second form was designed in 1948." (Note: The construction of these tubes with cylindrical electrodes had been attempted in the United States.)

"The 6AG7 tube is a pentode with indirect heating, designed for final broad-band (television power amplifier). The practical application of 6AG7 is not limited to television apparatus. Therefore 6AG7 must be considered as a tube which will have a large circulation in the future. This means that it must be developed along definite lines.

"Considerations about the metal and glass forms, and limitations of equipment arise in this case, similar to those concerning the 6AC7 tube. The electrical characteristics of the 6AG7 allow the distance to be increased between the grid and the cathode, which ensures effective mass production. In spite of the completion of the development of 6AG7, a second specimen of this tube has been constructed with an oval cathode. This work, which is a further modification, has in view not simply the copying

of a specimen of a tube. It is also intended to give the USSR industry new experience in development and construction which may be used not only for this type, but for other consequent independent designs. It must be observed that the creation of oval homogeneous designs of radio tubes is a more modern method of deciding the many questions of radio-tube construction.

"The use of oval high-frequency tubes is not yet employed in the USSR. The oval cathode in the tube 13 PIM was first used in the second World War for power-amplifying output tubes. From this example can be seen the enormous advantages which arise from the skilled use of oval cathodes. Together with the completion of the oval specimens of the 6AG7 tube there is also being produced the technology for the mass production of oval cathodes and grids." (Note: In the United States the space in the high-power tubes was widened, but it was not possible to do so in the high- tubes. The Russians apparently have more trouble handling close spacings than we do. Statement that oval design is a more modern method is questionable. Methods indicate fairly crude techniques for receiving-type tubes.)

"The 6J6 tube is a double triode in miniature form (so-called "finger" tube). It is designed to work as a high-frequency oscillator in push-pull arrangement with a power of approximately 1-1.5 watts. It works in the waveband between 50 cm and 4 meters. On account of its special application, the 6J6 tube has a common cathode for both of the separate triode systems." (Note: This tube is used in the United States mainly for low frequency.)

"This tube, although of small construction, possesses a relatively high anode dissipation. Owing to its short electrode leads, similar for both systems, it is suitable for push-pull circuits in the ultra-short to decimeter-wave range. It represents a copy of the corresponding American tube. Tubes of similar construction are the American tubes 53, 79, 6A6, 6N7, etc.

"The USSR radio tube industry has had some experience in copying similar "finger" tubes. Before the war a series of miniature "finger " tubes was constructed on the lines of the American ones, but the lack of productive ground work did not allow them to be mass produced. Therefore the construction of the 6J6 is proving to be a new type and will require a new technology and a new production technique."

Comparatively little information has been available on conditions surrounding the copying of the 829B tube. It is a radio-frequency beam-power amplifier and, as made by the OSW, represents a copy of the corresponding type of the American tube of National Union Radio Corporation. Indications are that production of this tube has not been very high as may be seen from the above tabulation.

"The 5D21 tube is a pulse amplifier built as a tetrode and is applied in the MEDDO equipment. It has an indirectly heated oxide cathode, intended to amplify pulses up to 15 amp with a duration of 0.001 sec. This tube is designed for work with high voltages on the anode, up to 20 kv when unloaded and 17.5 kv when loaded. The demands made are very great, and the construction itself is complicated. Thus the scope of the applications of this tube is limited, as it is impossible to mass-produce it. The tube is of American origin and appeared during the '1939-45 war.' It is a somewhat revised model of the tubes 715A and 715B produced earlier by Raytheon and also by Western Electric Company.

"The task in copying the 5D21 proved to be extremely difficult. On the basis of the experience of the factory "Telefunken" in producing the LV20, it was necessary to organize a second specimen, more closely related to it in its characteristics. The difficulty was increased by the lack of gold, which is required to gild the first and second grids of the tube in order to increase their heat-radiating capacity and give a smooth surface to the wires of the grids, thus ensuring a great sparking-over resistance for the tube. In view of the urgency of developing the tube, it was decided to overcome the

difficulty of the physical properties of the grids of the American tube 5D21 by altering its construction." (Note: This tube is not considered hard to make in the United States. It must be pumped to a high vacuum, and this is probably the trouble. Indications are of a possible lack of good sanitation in the Russian plant. The secondary emission is the main reason for needing the gold, and the other reasons are probably in error.)

"The lack of gold for gilding the grids would not allow the usual construction of this tube to be adopted. For example, to gild the grids of one 5D21 tube, approximately 200 milligrams of pure gold are required. This means practically that 1000 serviceable tubes would require approximately 1/2 kg of pure gold." (Note: These amounts of gold seem rather high.)

"Therefore the work in developing the 5D21 was applied in two directions:

Completing the urgent task of developing a tube based on the American 5D21 without using gold.

Investigating the question of decreasing the secondary and thermic emission from the grids of the tubes and bringing the construction up to the standard of the American original.

"Therefore the tube 5D21 produced on the basis of the original American one has two tetrode systems connected in parallel inside the glass vessel, instead of one. As a result there is a loss in the heat-dissipation of the electrodes on account of the increase in their surfaces.

"But this measure did not allow the tube to be constructed without the use of gold for gilding the grids.

"In the adoption of serial technology in the manufacture of the tubes it appeared that the specimens were likely to change their insulation when packed and transported. This deficiency forced a continuation of the development work on the tube beyond the period originally planned." (Note: What actually happens probably is that the tube gets gassy on the shelf.)

12. Cathode construction

Difficulty was being experienced in the experimental production of tungsten and molybdenum wire due to chipping and splitting of diamond tools in drawing the wire. As of 1 February 1949 it was reported that the Philips Company (Netherlands) would supply the USSR with diamonds, specially drilled by a secret process for drawing wire. The fact that diamond dies are a serious bottleneck even in the United States emphasized the hazard in wartime if access to the Philips organization is cut off.

Chrome-nickel wire of 22-24μ was being made, but great difficulty had been experienced in the wire-drawing shop with an 18-micron diameter.

A zircon paste composed of paraffin, naphthalin, and zircon is used as an intermediary layer between the thorium-oxide paste and the base metal. The zircon paste is sintered onto the tungsten carrier wire by passing a direct current through the wire in a high vacuum.

Another cathode paste, known as E4F7 Emission paste, has a composition of 50 percent $BaCO_3$, 45 percent $SrCO_3$, and 5 percent $CaCO_3$. The solvent is amyl acetate or Polysolvan E dissolved with 15 percent Intrasolvan.

There is a report that nickel and molybdenum may be in use as substitutes for tungsten. Molybdenum surfaces are prepared in an electrolytic bath of phosphoric and sulphuric acid.

Cathode tension springs are tempered to remove tensions which arise during winding by heating for 30 minutes in an electrically heated gas-proof furnace at about 1400°C.

Frequent complaints of shortages of materials are encountered in connection with wire and other metal parts for tube construction.

13. Bolometers

Of the several types of bolometers on which information has been available, only the two types OSW 2113 and 2183 seem to have had any appreciable production. The 2113 is classified along with thermal elements for maintaining constant voltage and the 2183 along with the measuring tubes and bolometers. Following are brief descriptions of some of them, together with their OSW numbers:

2090 Glass bolometer for outputs, 20 μw to 50 mw; λ= 3 cm
2091 Glass bolometer for outputs, up to 300 mw; λ= 3 cm
2092 Metal-ceramic bolometer, up to 50 mw; λ= 3 cm
2094 Measuring tube for max. output of 40 w; λ= 8 cm
2181 Measuring tube for outputs, 0.1 to 0.65 w; min λ about 3 cm
2182 Measuring tube for outputs, 0.3 to 1.8 w; min λ about 3 cm
2183 Measuring tube for outputs, 1 to 1.8 w; min λ about 3 cm
2184 Measuring tube for outputs, 9 to 120 w; min λ about 15 cm
2185 Measuring tube for outputs, 30 to 450 w; min λ about 50 cm
2510 Measuring tube for testing of OSW 2332 (slotless magnetron)
2519 Glass bolometer, 1 mw to 100 mw min λ about 3 cm
2520 Glass bolometer, 20 mw to 50 mw min λ about 2.5 cm
2113 Thermal element for maintaining constant voltage. 2 V $\pm$30% at 0.1 - 2.0 ma

Development of two bolometer-type output meters is described, type OSW 2395 for the 3- to 9-cm band and type OSW 2059 for the 8- to 12-cm band. Part of the general description is contained in the following two paragraphs.

The bolometric method is employed for measurement of power within the limits of 20 μw to 20 mw in the centimeter band and the lower part of the decimeter band.

The principle is as follows: The bolometer forms part of a special output meter which uses tuned coaxial-line sections or hollow waveguide sections. The bolometer itself is in the form of a cylindrical glass bulb, evacuated of air. A thin tungsten filament (10 to 12 microns diameter) runs along the length of the tube. The whole device is tuned and matched to the high-frequency generator under test, so that maximum power is developed across the bolometer. This develops heat, and alters the filament resistance, from which the r-f power can be measured. A bridge circuit is used to determine resistance variation. The bolometer filament forms one section of the bridge. (Note: Thermistors entirely replace this technique in the US.)

14. Other measuring instruments

Comparatively little information has been available on other measuring instruments. Ten types of output meters in ranges from 20 w to 500 w and wavelengths from 1.5 to 25 cm are listed. Eleven types of field strength meters in wavelength ranges from 3.1 to 200 cm are listed.

15. Detectors

At least three types of crystal detectors have been mentioned, the ED 704,705, and 707. Research is in progress on the growing of silicon monocrystals on carbon rods for use as detector crystals. So far it has not been possible to form the crystals sufficiently firmly on the carbon.

In the present detectors, silicon is condensed from silicon tetrachloride in both ends of the carbon rods at a temperature of 800°C. These are then bisected and used in the detector tubes 704, etc. No detectors for 4-mm waves are being manufactured; the lowest wavelength attained is 8 mm.

Sketched details of the mountings of ED 705 and 707 crystal detectors (Fig. 2) show in cross-section the placement of the detector and the arrangement of parts, together with some indications of the kinds of materials used.

16. High-temperature furnaces

Eighteen types of furnaces in temperature ranges from 1000° to 2400°C and from 25 x 300 cm to 125 x 100 cm in size are listed. Little further information is available except for description of shapes of the various types.

17. Refractory metals

Information of refractory metals is limited essentially to the items appearing under that heading in production figures and to the discussion of those and a few other items under the subject of cathode construction.

Ins

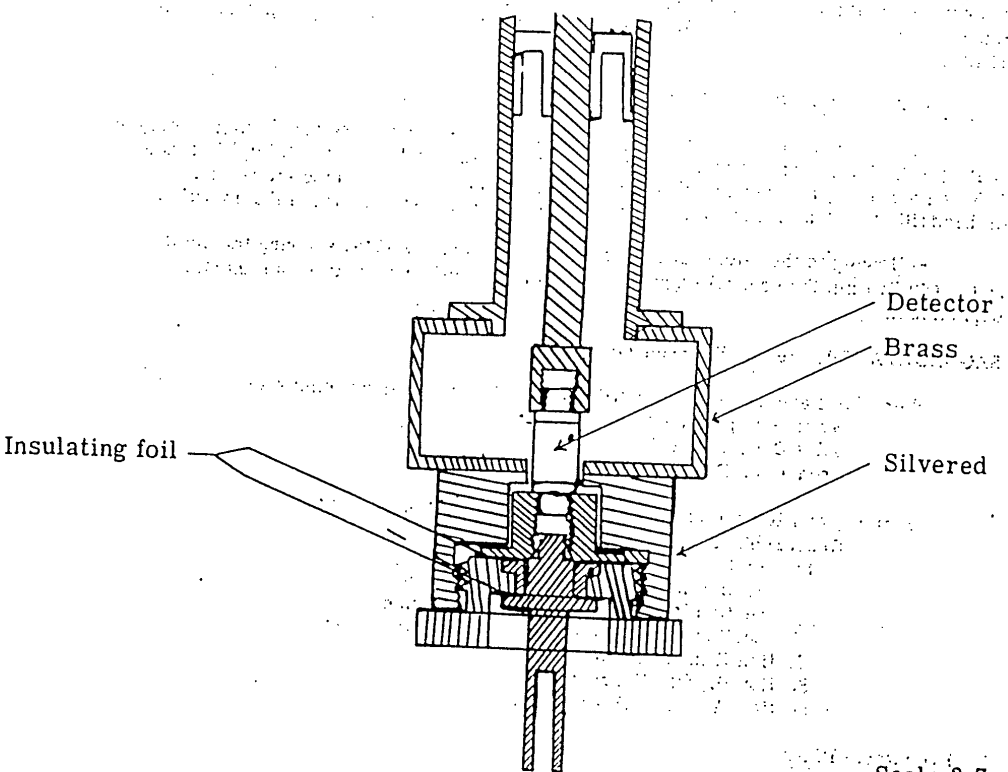

Fig. 2. Sketch of Mounting of ED 705 and 707 Crystal Detectors.

IV. PLANS FOR THE FUTURE

This consideration of plans for the future takes up the affairs of the organization from the point (near the end of 1948) where the discussion was terminated in Part I, POSTWAR ORGANIZATION. These are the indications for the present and near future on the basis of recent information (most of which became available during early 1949).

1. Present Form of Organization

As stated earlier the new designation for the OSW is "Werk fur Fernmeldewesen 'HF' (OSW), Zweigniederlassung der staalichen Aktiengesellschaft 'Isolator.'" Since 1 December 1948, the Russian officials of the plant have been wearing mufti, and civilian titles such as manager and director have been substituted for military titles.

Following is the latest tabulation (January-February 1949) showing the position of the OSW within the general framework and the organization of its experimental department:

SAG IZOLYATOR, Berlin-Weissensee

- Werk fur Fernmeldewesen "HF" (OSW), Berlin-Oberschoeneweide
  - Welfare Department
  - Sales Department
  - Production Plant
- Ministry of Electrotechnics, Moscow, Main Section V of SMA
  - Research and Experimentation Shop
    - Section I
      - Section Ia, Vacuum-tube Development
      - Section Ib, Television-tube Development
      - Section Ic, Development of Discharge Tubes
    - Section II (now Section Ic)
    - Section III, Oscillography
    - Section IV, General Technology

2. Production Plans

The production for 1949 is expected to amount to about 1,200,000 marks (east); straight reparations are calculated at 300,000 marks (east) for 1949. The remainder is to be used for export, for the SAG, and for German industry. (Note: As stated previously, the amount of production indicated here and on several following pages is very small and difficult to explain unless the figures refer to pilot plant or are deliberately distorted.)

Russian officials have ordered an analysis of the plant capacity, to determine (a) the investment necessary for a comprehensive increase in production, (b) the measures needed to reduce waste, and (c) the possibilities for increasing technical research.

Present production plans call for a doubling of the production of tungsten and molybdenum wire after 1 July 1949. The production of detectors, resistors, and resistor tubes of all sorts will hereafter be undertaken by other firms within the combine Izolyator. There were critical shortages in the fall of 1948, which seemed to suggest that production of many of the items would have to be discontinued; however, in the meantime, many of these shortages have been overcome by the ingenuity of the purchasing agent. He personally obtained from across the border quantities of ferro-nickel

for radio tubes and of aluminum for electrolytic condensers. The "Elektroapparate AG, Koppelsdorf," a branch of Izolyator, now handles most of the procurement of critical items for the entire combine.

Experiments with the production of artificial diamonds for certain industrial purposes have been successful.

During January 1949 representatives of the OSW took part in a conference concerning an agreement whereby Yugoslavian industries could import electrical equipment. No details concerning the agreement were reported.

The following digest gives the research and production plans for 1949 for the departments of vacuum-tube development and the development and experimental production of discharge tubes:

(1) High-writing-speed oscillograph for 150,000 km/sec and the further development of instruments and tubes. (Note: State of progress is a little behind the US. Only a few should be needed since it is used only for testing.)

(2) Investigation of the suitability of the high-output-cathode tube for the centimeter and decimeter region.

(3) Oscillographic presentation of centimeter and decimeter waves.

(4) Measurement of the radiation resistance of 3- and 10-cm waves.

(5) Measurement of the losses of detectors in measuring circuits.

(6) Measurement of the self-noise of detectors.

(7) Noise diode for the waveband from 0.8 to 2 cm, subdivided into four ranges.

(8) Wavemeters.

(9) Output meters.

(10) Test probes.

(11) Meter leads.

(12) Magnetrons.

(13) Spectrum analyzer.

(Nos. 8 through 13, like No. 7, are for the waveband from 0.8 to 2 cm, subdivided into four ranges)

(14) Overlapping wavemeters for the waveband from 3 to 10 cm.

(15) Factor-of-merit meters for 3 to 10 cm.

(16) Noise source for 3 to 10 cm.

(17) Voltage divider for 3 to 10 cm.

(18) "Ferrograph" for measuring the hysteresis loop in small amounts of magnetic material and in materials with limited magnetic properties.

(19) Double-magnet variometer with ferrite core.

(20) Further research on crystal detectors.

(21) Further research on the techniques on ceramics preparation.

(22) Development of a 3-inch television picture tube, together with components.

(23) Research work in the field of polar-coordinate picture tubes, together with components.

(24) Development of a (multiplying meter?) and the tubes and components.

(25) Further development of the large-screen projection apparatus and tubes and components.

(26) Improvement of the television process from 625 lines to at least 900 lines.

(27) Development and construction of an electric furnace for temperature of 3000°C.

(28) Construction of a machine for automatic production of a press directly from the glass melt.

(29) Construction of a machine for the automatic sealing of the press to the tubes.

(30) Construction of an automatic pump for fluorescent tubes.

(31) Construction of an automatic device for the assembly of cathode filaments of 11 micron tungsten wire.

This list of objectives is apparently weighted heavily with items concerning the production of tools and equipment and the development of manufacturing techniques rather than basic research.

3. Tube Production

An order was received at the OSW from the USSR at the end of January 1949 for the manufacture of 500 5D21 tubes. This order was refused by the Soviet management at the factory because the machinery was already fully occupied with orders and because of the shortage of molybdenum wire (or perhaps they didn't dare confess they could not make them).

The official research plan for 1949 for Department III (Production of Transmitting and Receiving Tubes) of OSW is as follows:

(a) Production of ten test samples of a noise-diode for 3 cm, Type OSW 2589. Date of completion is November 1949.

(b) Completion of ten noise-diodes for 10 cm. Date of completion is December 1949.

(c) Construction of three apparatus for testing the thermal grid-emission by the impulse method. Date of completion is December 1949.

(d) Construction of three sets of measuring equipment for the pulse output of tubes. Date of completion is December 1949.

(e) Construction of three sets of measuring apparatus for transient voltages and duration of oscillation. Date of completion is December 1949.

(f) Construction of three sets of measuring apparatus for high-frequency noise voltage. Date of completion is December 1949.

Other scheduled tasks are as follows:

Construction for Soviet Zone broadcasting stations of one water-cooled transmitting tube of each of types RS557(40 kw), RS558(40 kw), RS566(70 kw), RS366(140 kw). It is not known whether these were special orders or why the production was limited to single items.

OSW planned to start production in July 1949 of receiving-tube types 6SA7, 6J5, 6SK7, 6SQ7, 6V6, and 5Z4. The planned production date for types 6H6, 6E5, and 6L6 is December 1949. (Note: The 6E5 magic eye is one of the least essential US tubes.)

Another report states that the OSW is operating on a 24-hour day and priority has been given to the development of the 723 klystron to a 20-mw minimum. The daily production of 500 to 600 tubes of all types continues and a "memory" tube is under development. No further information concerning this memory tube has been reported.

It is said that a three-year plan (1949, 1950, and 1951) for the production workshop has been prepared, using production during 1948 as a basis. (Total expenditure on investment proposed for 1948 was 1,400,000 RM.)

4. Discharge lamps

The following excerpts are quoted on the prospects concerning discharge lamps and measuring apparatus:

"Small high-pressure lamps would undoubtedly find great demand in Germany and for export; since the producers of optical instruments are very interested in them and, so far, we are the only firm producing these lamps.

"Insofar as spectrum lamps are concerned the main demand is for sodium spectrum lamps and, therefore, in planning the production 50 percent of the total should be sodium spectrum lamps. However, for the production of sodium-spectrum lamps it is essential to have sodium-resisting glass, which cannot be, at present, produced in Germany. . . . (Note: No reason is given for not being able to produce sodium-resisting glass.)

"The expansion of markets (turnover) for very high-pressure lamps and large impulse lamps for photographic purposes must be planned with great care, since they still need a great deal of work on their development . . . .

"High-power neon tubes for lighting of aerodromes are apparently intended for the supply, first of all, to the Soviet Union. In the respect of these a certain increase in production is foreseen since the numerous queries from Russian undertakings lead one to expect a further increase in the demand."

5. Measuring Apparatus

"The workshop for making the apparatus and the small laboratory for testing the apparatus which we have at present are loaded to capacity with the development tasks laid down in the plan . . . .

"We must reckon that this state of affairs in the workshop and the laboratory for apparatus will not change in the subsequent years since you have instructed us that the development of apparatus will be carried on on the same scale.

"Each new production of apparatus entails the creation of a new workshop for making the apparatus, with complete mechanized equipment and instruments, and, also, a new laboratory for testing with quite expensive equipment. . . .

"The equipment for workshops, essential for the execution of (the program for apparatus) will require the outlay at a rough estimate of approximately 520,000 RM: the equipment of testing laboratories a further outlay of 350,000 RM.

"Area of essential premises 2,200 sq. meters

"Additional works personnel for 1949

17 Laboratory engineers
175 Specialist workers (male and female)
1 Production engineer
2 Foremen

"These figures rise, however, in 1950 to approx.

35 Laboratory engineers
350 Specialist workers (male and female)
1 Foreman

and in 1951 to:

38 Laboratory engineers
420 Specialist workers (male and female)
1 Foreman

"This program could certainly be reduced in which case the outlay for equipment, number of workers and the area of premises would be reduced also. Materials in short supply: Electrolytic condensers, electrical measuring instruments, and transformer iron."

6. Research and Development

"Five million marks (east) have been allocated for the 1949 research program. Fifteen percent of this sum was deducted for administrative costs by the SMA. The research which will be carried out in the OSW is to be but a part of a large research program, which, for greater security, will be conducted in Russia."

The experimental section of the OSW has developed a television set; an improved (Mechau?) projector was used and a good picture was obtained on a screen 1.5 meters by 2.0 meters.

Work has been discontinued on stabilizers and on spectral, high pressure, and impulse lamps, due to loss of personnel in these fields. Seven men experienced in the field of high frequency, particularly high-frequency tubes were among those taken to Russia in October 1946.

Along with these losses of personnel, another report concerning OSW transmitting tubes states that, "these and other tubes and much detailed production data and machinery have been transmitted to the USSR during the time OSW has been operating. . . ."

There appears to be a peak of effort concentrated at the 3-cm region, with somewhat smaller efforts at the 0.8-cm, 9.0-cm and 15- to 150-cm regions. As classified into output-power categories, the distribution appears as in the table below:

Band (Mc.)	Low Powers	Med. Powers	High Powers
Q(33,000-37,500)	All but one tube	One tube 500 watts	Few or none
K(11,000-30,000)	Most tubes	Few or none	Few or none
X(5,200-11,000)	20 to 500 mw)main	(3 tubes, 30-60 kw	Few or none
S(1,550- 5,200)	2 to 21 watts)region	(One tube 250 watts	1 tube 1000 kw
L(390- 1,550)	Few	Most	Few or none
P(225- 390)	Few	300 to 500 watts	Few or none

This discussion of plans for the future would not be complete without one highly important item which has come to attention concerning future security of the OSW organization. A recent report states that the Russian officials are becoming increasingly suspicious of the internal security of the plant and have increased the plant security force from 20 men to 40 men. This turn of events is not at all surprising in view of the comparatively large amounts of information which have been available for a rather long period. The size of the security force and the fact of its being doubled would seem to indicate that the Russian evaluation of the OSW's importance is still rather high even though the plant has been bled of materials and personnel to send to Russia in recent years.

V. CONCLUSIONS

The conclusions concerning the Oberspreewerke may conveniently be divided into three parts: (1) a summary of the information; (2) gaps in the information; and (3) the place of the OSW in the general scheme of things.

1. Summary of the Information

It should be emphasized that many details of information, particularly those concerning specifications and testing, have been considered too numerous and too low in importance to be included even in a specialized report. Such information is on file and will be available to the few persons, if any, who need it.

But because of the voluminous nature of even that part which has been extracted, a summary of the preceding pages has been attempted in the following pages.

The OSW has been considered one of the most important factors in the Russian electronics activity, particularly with regard to vacuum tubes. From the start of postwar operations in 1945 to the present time, at least four general reorganizations have apparently taken place. In October 1946, between two of these reorganizations, large scale deportations of personnel to Russia occurred. During this period the deportations were accompanied by the diversion of equipment and technical knowledge to Russia in order to facilitate electronics operations there. In the 1947-48 period the departure of several key persons resulted in a severe handicap to or complete closing of some departments. The control of the OSW was changed from the SMA to the Soviet AG Izolyator in January 1948, and the name was changed to "Werk fur Fernmeldewesen 'HF'" in January 1949.

Production efforts may apparently be grouped under five divisions:

a. Electrovacuum and gas-discharge instruments.
b. Radio measuring instruments.
c. Crystal detectors.
d. High temperature furnaces.
e. Refractory metals.

Of these categories the first is by far the largest, and also probably the most important, in view of the over-all objectives of the organization. Divisions b, d, and e appear to be operated at least partially in support of Division a.

Indications are that at least 200 different projects have been worked on from either the development or the production standpoint. Production seems to be highest on some of the American-type tubes, particularly the TV-amplifier tubes. Other items in relatively high production are the stabilizers or rectifiers, bolometers, cathode-ray tubes, metal-ceramic triodes, klystrons, and discharge lamps. Magnetrons have apparently been the object of much effort but rather low production.

It is estimated that approximately 100,000 tubes of all kinds were produced during 1947 by the OSW. The daily production in 1949 is estimated at 500 to 600 tubes of all types.

Much of the information on research and development is mixed in with large amounts of detailed specifications on construction and testing procedures for both experimental and mass production.

Considerable attention has been devoted to cathode-ray tubes, fluorescent materials, metal-ceramic tubes, magnetrons, and copies of several American tubes.

The preponderance of evidence from various sources indicates that the OSW has concentrated its greatest attention upon the following relatively small group of tubes:

OSW No.	Other Designation
2190	6AC7
2192	6AG7
2025	6J6
2026	829B
2027	5D21
2109	5FP7
2110	3DP1
2013	723A/B
2008	LD7/70
2006	LD9/90
2166	LD11
2044	LD12

Another very important list is that of tubes of importance to military purposes as classified by the Russian direction of OSW. In order of decreasing importance these are the 3DP1, 5FP7, OSW 2333, 5D21, 6J6, 6AC7, 6AG7, and 829B. Of this latter list all except the OSW 2333 are included in a seven-type program instituted for the express purpose of copying the corresponding American tubes.

Cathode-ray tubes under development at the OSW are said not to be for television purposes. There are among others (1) a polar-coordinate tube which may serve as an indicator of altitude in aircraft; (2) a tube for use in Panorama-vue equipment and in aircraft and ground stations; (3) a tube for screen projection which may be used in Panorama-vue equipment to permit the simultaneous viewing of the image by more observers.

Details of the color, composition, and other characteristics of at least fifteen fluorescent materials have become available. Difficulties have occurred in obtaining supplies of some of these materials.

Indications are that a considerable amount of progress has been made in the technology of metal-ceramic tube construction. A long period of experimentation beginning as far back as 1940 has resulted in the development and production of about 6 or 8 chief types. Much research has gone into the development of suitable soldering materials and techniques.

Along with the metal-ceramic tube technique, the magnetrons have probably received the greatest emphasis. Much research has been devoted to the slotless model and others in the shorter wavelength range. The plan for various frequency ranges is said to be:

Wavelength from 8 to 12 cm - the continually tuning magnetron.
Fixed wavelength of 6 cm - the slotless magnetron OSW 2332 Type A.
Wavelength from 2 to 4 cm - the magnetron 2332A or a new tube still in the development stage.
Fixed wavelength of 1 cm - the 8-slot magnetron (apparently the one later designated as OSW 2585).

Of approximately 20 various types of magnetrons to which reference has been made at one time or another, only two, the OSW 1200 Haban-tube (with anode inside cathode) and the 2332 slotless magnetron, appear to have had any appreciable production up to a recent date.

The copies of American tubes are very similar to the originals except for minor changes of design which were made necessary by lack of certain materials or equipment (as the substitution of glass for metal tubes and the lack of gold for gilding the grids of the 5D21). The copying of the 5D21 in spite of extreme difficulties would seem to indicate appreciable importance of this tube in the Russian program.

In the present crystal detectors silicon is condensed from silicon tetrachloride on carbon rods at 800°C. No four-mm detectors are being manufactured: the lowest attained is eight mm.

The OSW produces tungsten and molybdenum wire and plates for tube construction but has been hampered by shortages of these materials and (in drawing of fine wire) by the high breakage rate of diamond dies.

Plans for the future call for the further development of tubes with high writing speeds, a doubling of the production of tungsten and molybdenum wire, oscillographic presentation of centimeter and decimeter waves, measurement of the radiation resistance of 3- and 10-cm waves; further research on crystal detectors, further research on the techniques of ceramics preparation, further development of the large-screen projection apparatus, improvement of the television process from 625 lines to at least 900 lines, a doubling of the production of tungsten and molybdenum wire, and a number of other items mentioned elsewhere.

Five million marks (east) have been allocated for the 1949 research program. The research which will be carried out in the OSW is to be but a part of a large research program, which, for greater security, will be conducted in Russia.

2. Gaps in the Information

At the outset these two facts should be mentioned:

(a) The judgment as to the existence of gaps will have to be based to a large extent on the table of organization as a guide, and to a less extent on the tabulation of production.

(b) The large amount of information which has become available concerning the OSW seems to have left relatively few gaps if these outlines of organization are reasonably complete.

There has been a definite scarcity of information on actual production figures, especially for 1948 and 1949. There is less specific information on production by items in 1948 than in 1947 and very little at all in 1949. Perhaps the most important single item of information for 1949 is the estimated daily production of 500 to 600 tubes of all types. The low production figures, in terms of dollars, which are quoted repeatedly are an especially puzzling gap in the information.

The tightening of production information may be due to suspicions of security laxity, or to a disappointingly low production level, or to both.

Production on magnetrons has been low unless the information has been more highly guarded because of its great importance in connection with radar equipment. The question of whether or not radar equipment is being manufactured by the OSW is unresolved, but in general the organization seems to have limited itself mostly to vacuum tubes.

A moderate amount of attention has been given to the production of discharge lamps, but how much is toward the supplying of a general demand and how much toward special military uses is not clear. Neither is it very clear what the complete relationship

of activity in the fields of radio measuring instruments and high-temperature furnaces is to other fields. The high-temperature furnaces are not unusually large compared to those in the United States but, nevertheless, are fairly large in size.

3. Place in the General Scheme of Things

There can be little doubt that the OSW has been one of the bulwarks of the USSR vacuum-tube program, at least in the Occupied Zone and probably also in Russia. The importance to the latter has been evident in the removal to Russia of personnel, equipment, and information on techniques.

Judging from the amount of emphasis placed on research and development in connection with magnetrons the OSW is of prime importance in radar development which, in turn, is of prime importance in defense plans.

There is a long history of experimentation, development, and production in metal-ceramic tubes such as would indicate both an interest and an accomplishment of considerable dimensions in this field. Future progress, however, may be delayed by the reported loss of some of the key personnel.

Cathode-ray tubes appear to be another item of present and future importance to the OSW. The production of copies of American tubes is a major item, and since it includes the 5D21, applicable to radar use, emphasizes still further the radar aspect.

Accomplishments at the OSW, both in quality and quantity of output, appear to have lagged somewhat, possibly because of the partial stripping of plant facilities. But prospects for the future of OSW both in its own production and in furnishing equipment and plans to the Russian organizations could be quite good if the officials so choose by avoiding a complete dismantling.

The concern of the officials over the present security and the plan for doubling the security force strengthen the belief that considerable importance is attached to the future of OSW.

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